

AMENDMENTS

Amendments to the Claims

This listing of claims will replace all prior versions and listings of claims in the application:

Claims 1 - 4 (cancelled).

*Resubmitting
in Red*

⁸
Claim ~~8~~ (previously presented): A highly energy-efficient pure vacuum swing gas adsorption and separation system for separating a predominate oxygen gas mixture from supplied air feedstock gas, the system comprising:

- (a) a first conduit system for transporting the supplied air feedstock gas to be separated;
- (b) two horizontally-oriented adsorption-desorption vessels connected to the first conduit system and in communication with an inner conduit system, each adsorption-desorption vessel and the inner conduit system configured to alternatively perform adsorption and desorption cycles, each vessel having
 - (1) a horizontally-oriented cylindrical outer shell assembly having two ends and at least one inlet for supplying the flow into the cylindrical outer shell assembly of the air feedstock gas to be separated,
 - (2) two closure means for sealing the cylindrical outer shell assembly, one closure means secured to each of the ends of the cylindrical outer shell assembly,
 - (3) a nozzle assembly, attached to one of the closure means of the cylindrical outer shell assembly, through which the separated oxygen gas mixture is evacuated, and

- (4) an adsorption bed assembly contained in the cylindrical outer shell assembly, the adsorption bed assembly including a molecular sieve bed assembly having one or more layers of perforated or porous mesh material and a predominate nitrogen-selective material contained within the mesh material, configured such that the air feedstock gas is separated as it passes through the adsorption bed assembly leaving gross product predominate oxygen gas mixture to be evacuated through the nozzle of each adsorption-desorption vessel;
- (c) a control means for sequentially cycling and controlling the adsorption-desorption vessels such that when one of the adsorption-desorption vessels performs an adsorption cycle the other vessel performs a desorption cycle;
- (d) a second conduit system connected to the nozzles of the adsorption-desorption vessels for transporting the gross product predominate oxygen gas mixture separated in the adsorption-desorption vessels for collection;
- (e) a first compressor located downstream of and in communication with the adsorption-desorption vessels and the second conduit system, the first compressor configured to induce the flow of air feedstock gas into the adsorption-desorption vessels during each vessel's adsorption cycle and extracting the flow of gross product predominate oxygen gas mixture out of adsorption-desorption vessels exclusively through vacuum pressure;
- (f) a second compressor and third conduit system in communication with the adsorption-desorption vessels, the second compressor configured to remove predominate residual nitrogen and lesser oxygen gases contained in the adsorption-desorption vessels during the

desorption cycle through the third conduit system by inducing vacuum extraction of the predominate nitrogen and lesser oxygen gases and by purging the vessels with a portion of the gross product predominate oxygen gas mixture supplied upstream from the first compressor, thereby leaving a net product predominate oxygen gas mixture to be collected downstream of the first compressor.

⁹
Claim ~~6~~ (previously presented): The highly energy-efficient pure vacuum swing gas adsorption and separation system of claim ~~5~~⁸ additionally including a heat exchanger located downstream of the adsorption-desorption vessels and upstream from the first compressor, the heat exchanger configured to cool the gross product predominate oxygen gas mixture.

¹⁰
Claim ~~7~~ (previously presented): The highly energy-efficient pure vacuum swing gas adsorption and separation system of claim ~~6~~⁹ additionally including:

- (a) a first heat exchanger located downstream of the first compressor for cooling the net product predominate oxygen gas mixture after it is compressed by the first compressor;
- (b) a third compressor located downstream of the first heat exchanger for compressing the net product predominate oxygen gas mixture after it is cooled by the first heat exchanger;
- (c) a second heat exchanger downstream of the third compressor for cooling the net product predominate oxygen gas mixture after it is compressed by the third compressor; and
- (d) a fourth compressor located downstream of the second heat exchanger for compressing the net product predominate oxygen gas mixture after it is cooled by the second heat exchanger.

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Claim 8 (currently amended): The highly energy-efficient pure vacuum swing gas adsorption and separation system of claim ⁸5 additionally including a preheater located upstream from the adsorption-desorption vessels, the preheater configured to heat the air feedstock gas before entry into the ~~adsorption-desorption vessels~~ adsorption-desorption vessels.

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Claim 9 (previously presented): The highly energy-efficient pure vacuum swing gas adsorption and separation system of claim ⁸5 additionally including a pressure stabilizing tank located downstream of the first compressor.

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Claim 10 (previously presented): The highly energy-efficient pure vacuum swing gas adsorption and separation system claim ⁸5 wherein the axial length of each adsorption-desorption vessel is at least two times the diameter of the vessel.

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Claim 11 (previously presented): The highly energy-efficient pure vacuum swing gas adsorption and separation system of claim ⁸5 wherein the adsorption bed assembly of at least one adsorption-desorption vessel comprises one or more cartridges that may be integrally removed from the vessel and replaced.

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Claim 12 (previously presented): A horizontally-oriented, radial-flow adsorption-desorption vessel for separating a predominate oxygen gas mixture from air feedstock gas, the vessel comprising:

(a) a horizontally-oriented cylindrical outer shell assembly having an inner surface, two ends, and at least one inlet for supplying the flow into the cylindrical outer shell assembly of the air feedstock gas to be separated;

(b) two closure means for sealing the cylindrical outer shell assembly, one closure means secured to each of the ends of the cylindrical outer shell assembly;

(c) a nozzle assembly, attached to one of the closure means of the cylindrical outer shell assembly, through which the separated predominate oxygen gas mixture is evacuated; and

(d) an adsorption bed assembly contained in the cylindrical outer shell assembly and supported by one or more supports attached to the inner surface of the cylindrical outer shell assembly, the adsorption bed assembly having

(1) an outer shell, having an inner surface,

(2) an inner central pipe, having an outer surface, and oriented generally along the axis of the cylindrical outer shell assembly and in communication with the nozzle assembly, the inner central pipe configured to collect the flow of separated predominate oxygen gas mixture and direct the separated predominate oxygen gas mixture to the nozzle assembly for evacuation, and

(3) a molecular sieve bed assembly contained between the outer shell of the adsorption bed assembly and the inner central pipe, the molecular sieve bed assembly having one or more layers of perforated or porous mesh material and a predominate nitrogen-selective material contained within the mesh material.

¹⁶
Claim ~~13~~¹⁵ (previously presented): The vessel of claim ~~12~~¹⁵, wherein the axial length of the vessel is at least two times the diameter of the vessel.

¹⁷
Claim ~~14~~¹⁵ (previously presented): The vessel of claim ~~12~~¹⁵, wherein the adsorption bed assembly additionally includes at least two partitions, each having two ends, one end connected to

the outer surface of the inner central pipe and the other end connected to the inner surface of the outer shell of the adsorption bed assembly.

¹⁸
Claim ~~15~~ (previously presented): The vessel of claim ¹⁵~~12~~, wherein the adsorption bed assembly comprises one or more cartridges that may be integrally removed from the vessel and replaced.

²⁰
Claim ~~16~~ (previously presented): The vessel of claim ¹⁵~~12~~, wherein the adsorption bed assembly additionally includes at least four partitions, each having two ends, one end connected radially to the outer surface of the inner central pipe and the other end connected radially to the inner surface of the outer shell of the adsorption bed assembly, the partitions are spaced to form cross-sections between them that narrow from the inner surface of the outer shell to the outer surface of the inner central pipe such that the velocity of the predominate oxygen gas mixture entering the inner central pipe through the cross-sections is approximately equal to the velocity of the air feedstock gas entering the adsorption bed assembly.

¹⁹
Claim ~~17~~ (previously presented): The vessel of claim ¹⁸~~15~~, wherein the adsorption bed assembly additionally includes at least four partitions, each having two ends, one end connected radially to the outer surface of the inner central pipe and the other end connected radially to the inner surface of the outer shell of the adsorption bed assembly, the partitions are spaced to form cross-sections between them that narrow from the inner surface of the outer shell to the outer surface of the inner central pipe such that the velocity of the predominate oxygen gas mixture entering the inner central pipe through the cross-sections is approximately equal to the velocity of the air feedstock gas entering the adsorption bed assembly.

Claim 18 (previously presented): A highly energy-efficient pure vacuum swing gas adsorption and separation process for separating a predominate oxygen gas mixture from air feedstock gas, the process comprising:

(a) supplying the air feedstock gas from which the predominate oxygen gas mixture will be separated to two horizontally-oriented adsorption-desorption vessels in communication with an inner connecting conduit, each vessel and the inner connecting conduit configured to alternatively perform adsorption and desorption cycles and the vessels having nitrogen-selective adsorbent material capable of separating a predominate oxygen gas mixture from the air feedstock gas;

(b) inducing the flow of air feedstock gas into the first adsorption-desorption vessel during the adsorption cycle and extracting the flow of the gross product predominate oxygen gas mixture out of the first adsorption-desorption vessel exclusively through vacuum pressure created by a first compressor in communication with and positioned downstream of the first and second adsorption-desorption vessels;

(c) removing residual predominate nitrogen and lesser oxygen contained in the second adsorption-desorption vessel during the desorption cycle by inducing vacuum extraction of the predominate nitrogen and lesser oxygen through a second compressor and by purging the second adsorption-desorption vessel with a portion of the gross product predominate oxygen gas mixture supplied upstream from the first compressor, thereby leaving a net product predominate oxygen gas mixture to be collected downstream of the first compressor;

(d) sequencing the first and second adsorption-desorption vessels such that after one vessel completes an adsorption cycle it begins a desorption cycle and as the other vessel completes a

desorption cycle it begins an adsorption cycle, with each cycle being of approximately equal time duration; and

(e) continuing this series of steps to produce a desired amount of separated predominate oxygen gas mixture.

²
Claim ~~19~~ (previously presented): The process of claim ¹~~18~~ additionally including the step of exhausting to atmosphere the extracted residual predominate nitrogen and the gross product predominate oxygen gas mixture supplied upstream from the first compressor used to purge an adsorption-desorption vessel during the desorption cycle.

³
Claim ~~20~~ (previously presented): The process of claim ¹~~18~~, wherein the sequenced adsorption and desorption cycles are approximately 30 seconds each.

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Claim ~~21~~ (currently amended): The process of claim ¹~~18~~ additionally including the step of cooling the gross product predominate oxygen gas mixture by passing the gas mixture through a heat exchanger located downstream of the adsorption-desorption vessels and upstream of the first compressor, the cooling step performed before a portion of the gross product predominate oxygen gas mixture is used to perform the purging step of ~~14(e)~~ ¹~~18(c)~~.

⁵
Claim ~~22~~ (previously presented): The process of claim ¹~~18~~ additionally including the step of using a pressure stabilizing tank located downstream of the first compressor for maintaining a relatively even pressure of the net product predominate oxygen gas mixture.

⁶
Claim ~~23~~ (previously presented): The process of claim ¹~~18~~ additionally including the step of conditioning the air feedstock gas before it enters the adsorption-desorption vessels.

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Claim ~~24~~ (previously presented): The process of claim ⁶~~23~~, wherein the conditioning step
comprises preheating the air feedstock gas.